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U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

SILVICAL CHARACTERISTICS OF YELLOW-POPLAR
(Liriodendron tulipifera L.)

by

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Yellow-poplar (Liriodendron tulipifera L.) is also commonly known as tulip poplar, tuliptree, white-poplar, whitewood, and "poplar" (35). It gets its name from the tulip-like flowers which it bears in the late spring. Because of the excellent form and rapid growth rate of the tree, plus the fine working qualities of the wood, yellow-poplar is one of the most important hardwood species in the United States.

Yellow-poplar is found throughout the eastern United States from southern New England west to Michigan and south to Florida and Louisiana (19). It is most abundant and reaches its largest size in the valley of the lower Ohio basin and on the slopes of the mountains of North Carolina, Tennessee (47), Kentucky, and West Virginia.

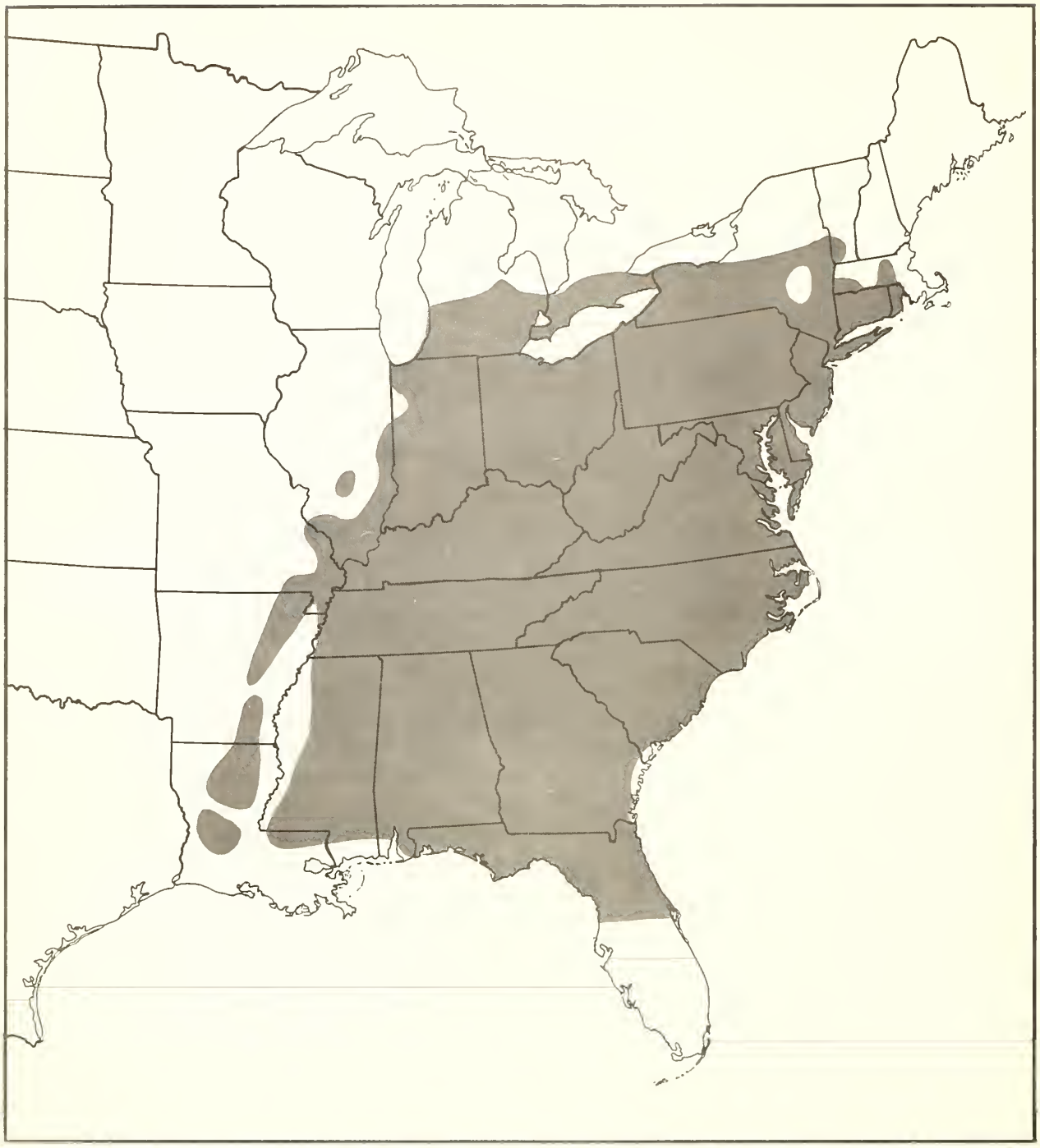
HABITAT CONDITIONS

CLIMATIC

Because of its wide occurrence, yellow-poplar grows within a broad range of climatic conditions. Temperature extremes vary from the moderately severe winters of southern New England to almost frost-free central Florida. Similarly, the range of rainfall varies within the territory from 30 inches to more than 80 inches for restricted areas in the Southern Appalachians (54). Its optimum development occurs where rainfall is well distributed over a long growing season. In a study in West Virginia, it was found that adequate rainfall early in the growing season had more effect on diameter growth than total rainfall during the entire season (53).

EDAPHIC

For good growth and form, yellow-poplar is quite exacting in its soil and moisture requirements. Where it occurs naturally, the sites are almost always moderately moist, well drained soils of loose texture, and it rarely grows well in very dry or very wet situations (38).



Botanical range of yellow-poplar.

In the Central States, Auten (2, 3) found that depth of A_1 horizon and depth to a tight subsoil were directly correlated with site index; in general, the presence of a tight subsoil less than 24 inches below the surface indicated a less than average site. Auten's relationship of height, age, and depth of A_1 horizon is:

Height (in feet) = 1.125 (age in years) + 2.62 (depth of A_1 horizon in inches) + 23.06

In the Piedmont of North Carolina, the site indices of yellow-poplar and loblolly pine are similar on good sites. On lower slopes and alluvial soils the site index of yellow-poplar can be predicted by Coile's (13) loblolly pine equation for lower slopes; depth of A horizon and imbibitional water value of the B horizon are the important soil factors in this equation: 1/

$$\text{Site index} = 110.11 - \frac{101.0}{\text{depth of A horizon}} - 1.98 \text{ (imbibitional water value)}$$

Another study of yellow-poplar and loblolly pine in the North Carolina Piedmont also showed that there was no difference between the site indices of the two species on good sites and that on sites where yellow-poplar is found, depth of A horizon alone gives an approximate estimate of site quality: 2/

Site index = 74.88 + 0.7163 (depth of A horizon)

Within the range of soils which he studied, Auten (3) found no correlation of site quality with calcium, magnesium, phosphorous, potassium, or with soil reaction (pH). Although the content of nitrogen in the soil varied from one area to another, it was not always consistent in its relation to site.

However, it is a well known fact that certain species of trees improve the fertility of the soil. A good example of this is shown by the effect of black locust on soil nitrogen and on the growth rates of associated species in 25-year-old forest plantations in Ohio and Indiana (11). Yellow-poplar planted close to black locust grew best; it definitely showed decreasing height and diameter growth with increasing distance from the locust. The soil under the yellow-poplar also showed a decrease in nitrogen with increasing distance from the locust.

PHYSIOGRAPHIC

At the northern end of its range, where low temperatures are a limiting factor, yellow-poplar is usually found in valleys and stream bottoms and at elevations below 1,000 feet. In the Appalachian Mountains, yellow-poplar

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1/ Metz, Louis J. Site indices of yellow-poplar and redgum on alluvial soils in the vicinity of Durham, N. C. 31 pp., 1947. (Unpublished M. F. thesis, School of Forestry, Duke Univ., Durham, N. C.)

2/ Hocker, Harold W. Jr., Relative growth and development of loblolly pine and yellow-poplar on a series of soil sites in the lower Piedmont of North Carolina. 40 pp., 1953. (Unpublished M. F. thesis, School of Forestry, N. C. State College, Raleigh, N. C.)

is at its optimum, and it grows on a wide variety of sites including stream bottoms, coves, and on slopes which have suitable moisture conditions--up to a maximum elevation of 4,500 feet in the Southern Appalachians. Toward the southern limit of the range, where high temperatures and soil moisture probably become limiting factors, the species is usually confined to well drained stream bottoms.

Aspect, position on slope (2, 40), and elevation are important topographic factors having an influence on the site quality for yellow-poplar.

BIOTIC

Yellow-poplar is a component of 16 of the 106 cover types listed for North America (50). It is the major species in 4 of these types, which are characterized by: (1) pure yellow-poplar; (2) yellow-poplar and hemlock; (3) yellow-poplar, white oak, and northern red oak; and (4) sweetgum and yellow-poplar.

On bottomlands and the better drained soils of the Coastal Plains yellow-poplar occurs in mixture with the gums, baldcypress (Taxodium distichum), the oaks (Quercus sp.), red maple (Acer rubrum), and sometimes loblolly pine (Pinus taeda).

In the Piedmont, associated species include the oaks, sweetgum (Liquidambar styraciflua), blackgum (Nyssa sylvatica), red maple, American elm (Ulmus americana), loblolly pine, shortleaf pine (Pinus echinata), and hickories (Carya sp.).

At the lower elevations in the Appalachian Mountains, it is found with black locust (Robinia pseudoacacia), white oak (Quercus alba), white pine (Pinus strobus), eastern hemlock (Tsuga canadensis), and black walnut (Juglans nigra), along with minor components of the hickories, other oaks, and yellow pines, together with flowering dogwood (Cornus florida), sweet birch (Betula lenta), blackgum, basswood (Tilia sp.), and silverbell (Halesia carolina). At the higher elevations associated species include northern red oak (Quercus rubra), white ash (Fraxinus americana), black cherry (Prunus serotina), cucumber tree (Magnolia acuminata), buckeye (Aesculus sp.), American beech (Fagus grandifolia), sugar maple (Acer saccharum), and yellow birch (Betula alleghaniensis). Species associated with yellow-poplar in nonmountainous areas of the North and Midwest include white oak, black oak (Quercus velutina), northern red oak, ash, beech, sugar maple, blackgum dogwood, and the hickories.

The twigs and branches of yellow-poplar are tender and tasty to livestock and white-tailed deer (Odocoileus virginianus), and young trees are often heavily browsed. Seedlings are grazed to the ground, small saplings are trimmed back, and even large saplings may be ridden down and severely damaged. On areas where animals are concentrated, young yellow-poplar is frequently wiped out. Rabbits also eat the bark and buds of seedlings and saplings, and can be quite destructive at times.

Other animals seek out the seed of yellow-poplar. Some of these animals are: quail (Colinus virginiana), purple finch (Carpodacus purpureus), cardinal (Cardinalis cardinalis), cotton-tail rabbit (Sylvilagus floridanus), red squirrel (Sciurus hudsonicus), gray squirrel (Sciurus carolinensis), and the white footed mouse (Peromyscus sp.) (37, 56).

LIFE HISTORY

SEEDING HABITS

Flowering and Fruiting

Yellow-poplar flowers from April to June (55), depending on geographic location and the weather. The flower of yellow-poplar is tulip-like in form and size, and is one of the favorite sources of nectar for honey bees. In fact, it has been suggested that the percentage of sound seed is directly related to the number of honey bees visiting the flowers.

The fruit is a cone-like aggregate of many winged carpels or samaras borne on a central spike. About 80 winged carpels are produced in each fruit (9), and each carpel bears two seeds, one usually aborted. Fruits begin to mature in late September.

Seed Production

Although yellow-poplar is a prolific seeder, few seeds per strobile are fertile--the rest are empty seed coats. Germination tests of stratified seed showed a low of 1 percent, a high of 14 percent, and an average of 5 percent (55).

Bumper crops of seed occur only at irregular intervals, but studies at Duke University show that a seedfall of 300 thousand or more seeds per acre is not uncommon (9). Cutting tests in this study gave an average of 11.1 percent of sound seeds for a 3-year period; however, cutting tests usually show a much higher viability of seed than germination tests. Trees with larger diameters produce both a greater number of cones and a greater number of sound seeds than trees of smaller diameter. For example, at Duke a 10-inch tree produced about 750 cones and 7,500 sound seeds, but a 20-inch tree produced 3,250 cones and 29,000 sound seeds.

The minimum seed-bearing age is 15 to 20 years, and the maximum age is undetermined, but it is known to be more than 200 years. In Indiana, trees 15 inches and less in diameter yielded as high a proportion of filled or good seed (on a per-tree basis) as larger trees, and sometimes higher; seed from the upper two-thirds of the crown was better filled than seed from the lower third (18). Also, trees in closed stands did not have a higher proportion of filled seed than trees in open stands, and site or soil fertility was not a factor within the limits of this study in determining quality of the seed harvested.

Wean and Guard (60) have determined that trees in Indiana vary widely in the production of viable seed, and that a given tree is consistent through the years in the production of a given viability. A low producer will be consistently low, and a high producer will be consistently high over the years.

Carpenter and Guard (8) found that cross pollination of yellow-poplar in Indiana increased the percent of filled seed per cone up to as high as 90 percent, where the highest for open-pollinated seed was 34.8 percent. At the end of 4 months after germination, seedlings from the cross-pollinated seed were taller than seedlings from the open-pollinated seed, and the largest seedling from a cross had about twice the height of the largest seedling from open-pollinated seed. This study indicates that by planting together seedlings from widely separated seed parents, seed will be produced which will give both improved germinative capacity and more vigorous seedlings.

Seed Dissemination

As they dry in the cone, the individual winged seeds are scattered by the wind to distances equal to four or five times the height of the trees (38). At Duke University (9), seedfall began in early October and reached a peak in early November. Sound seed was disseminated from mid-October to mid-March; seed falling early and late had about the same percentage of soundness.

Seed dissemination is generally high during warm, dry weather and low during cool, wet weather.

VEGETATIVE REPRODUCTION

Several investigators have tried to root yellow-poplar cuttings, but no results have been satisfactory (4, 25).

Although yellow-poplar sprouts readily and vigorously from stumps and rootstocks, and frequently grows and develops satisfactorily in clumps, sprout stands are not as desirable as stands from seed. Trees of sprout origin are not only more apt to develop heart rot than are seedlings, but sprouts often grow from small stumps which rot quickly, leaving little support against ice and wind damage. Sprouts from small stumps and rootstocks or seedling sprouts do have tremendous vigor and can usually outgrow the sprouts of any other competing species, as well as seedlings of the same species.

McCarthy (38) regards the sprouting ability of yellow-poplar as a safeguard in case young seedlings are destroyed by fire, or as a last resort where clearcutting for pulpwood in young stands has left little or no seed. It is recognized today that many young new stands have developed from sprout origin, and this recognition is important, because of the extra need for cultural attention during the early years.

SEEDLING DEVELOPMENT

Establishment

The successful regeneration of yellow-poplar calls for adequate seed, a seedbed of mineral soil, adequate soil moisture, sufficient direct sunlight for early growth, and some shelter for the seedlings by a light cover of grasses, shrubs, and trees (9, 38).

Eight to ten seed trees (14 to 20 inches in d.b.h.) per acre are considered necessary for the regeneration of cutover land in the Piedmont of North Carolina (9). However, as often happens in the mountains, one large seed tree favored by topography and prevailing winds may seed in an area of several acres (17). If logging is done during the fall or winter, and seed trees are not considered necessary for insurance, seed from the trees removed in cutting may be sufficient to regenerate cutover areas.

While an area is being cut and logged, proper seedbed and light conditions can usually be provided. It is important that the forest floor is scarified, and if this is not accomplished during logging or if logging is not done during the dormant season, it may be necessary to employ additional means of scarification. Seed that does not immediately reach mineral soil may remain dormant for a year or perhaps longer (38).

Sims (49) points out that burning following clear cutting may be desirable for preparing a seedbed. Although burning may be a good idea on areas with a heavy accumulation of raw humus, regeneration can usually be accomplished without burning.

After germination, several critical years follow. During this period sufficient soil moisture must be available; good drainage and protection against drying and frost heaving are necessary, and there must be no severe competition from nearby sprout growth.

The method of cutting yellow-poplar to get regeneration can be quite flexible. Several methods have been successfully used in the past, including clearcutting, seed tree cutting, and group selection. The important criteria of a good cutting method are that it must not only leave an adequate seed source and a mineral seedbed, but the surrounding cutover area must be large enough to allow for growth of the new crop.

Yellow-poplar can be planted successfully, provided sufficient care is exercised in selecting the site and in the planting itself. Yellow-poplar should not be planted on dry, exposed, old-field sites (38, 41, 48) because the few seedlings that survive make poor growth.

Minckler (40, 42, 43) found that north and east exposures should be favored for planting yellow-poplar, and steep south slopes should be avoided in the Appalachian Valley of Tennessee. The planting site should not be eroded, and there should be at least 12 inches of topsoil present. The site

should be moist but well drained, preferably with a light to moderate cover of vegetation. Minckler also lists other factors affecting plantation success as follows: soil type, first year precipitation, permeability and porosity of the soil, and rodent activity.

In addition to advising against planting on dry old-fields in Michigan, Shipman and Rudolph (48) recommend planting on borders or in small openings to provide side shading and protection against sun-scald damage.

At the end of 5 years, records of planted yellow-poplar in northern Mississippi show that release is necessary to attain satisfactory survival and height growth on lower slopes and bottomlands--the two sites where this species does best (62).

Excellent height growth of planted yellow-poplar has been attained in the Central States by planting in mixture with black locust on old fields (12) and by underplanting in 8- and 9-year-old black locust plantations on strip-mined land (15).

A recent study of preplanting treatments in Ohio (39) showed that in old fields yellow-poplar seedlings made the greatest height growth when planted on the "lay" or overlap of a double furrow.

Yellow-poplar plantings in the Central States show the importance of grading seedlings and improving nursery techniques (33, 34). In southeastern Ohio (34), the heights of 5-year-old seedlings originally graded to a 6/20-inch stem diameter (1 inch above ground line) were 1 foot taller than seedlings that had been graded to 3/20 inch. Seedlings 15 inches high at time of planting were 1 foot taller than seedlings that had been 5 inches high at time of planting. A combination of root pruning and grading of seedlings improved survival even more (33).

In the Southern Appalachians (29), planting yellow-poplar proved to be much more reliable than direct seeding in spots. After 4 years, only 40 percent of the seed spots had seedlings surviving, while 95 percent of the planted seedlings were living. Seedlings on seed spots averaged only 0.10 foot in height, as contrasted with 1.27 feet for planted seedlings.

Because of their carrot-shaped or wedge-shaped taproot, yellow-poplar seedlings are frequently lost to frost heaving, particularly those planted on clay.

Early Growth

On favorable sites the success of regeneration can usually be determined by the size and vigor of seedlings at the end of the third year. Height growth during the first year ranges from a few inches to more than a foot on the best sites. With full light, rapid height growth begins the second year, and at the end of 5 years heights may be 10 to 18 feet. McCarthy (38) cites one example of a yellow-poplar of seedling origin which was 50 feet in height at 11 years of

age. Yellow-poplar is inherently capable of making extremely rapid growth, especially during its seedling and sapling stages; rapid height growth is also assisted by the good sites on which it generally grows.

Toumey (52) describes the root system of yellow-poplar as having a rapidly growing and deeply penetrating juvenile taproot, as well as many strongly developed and wide-spreading lateral roots or sinkers. He states that root habits are inherent with a species and they are usually less flexible or adaptive to environment during the juvenile period than in later years. However, yellow-poplar is considered by Toumey to have a flexible rooting habit, even in the juvenile period.

The behavior and duration of height growth of yellow-poplar has been found to vary by latitude. In Pennsylvania (26) yellow-poplar seedlings had a 95-day height growth period beginning late in April and ending about August 1. A sharp peak in height growth was reached about June 1. In northwestern Connecticut (28) yellow-poplar had a 110-day height growth period beginning in late April and ending in mid-August. Ninety percent of its height was put on in a 60-day period from May 20 to July 20. A sharp peak in height growth was noted in the middle of June. In the lower Piedmont of North Carolina (32) yellow-poplar had a 160-day period of height growth, beginning in early April and ending about the middle of September. However, height growth was more constant throughout the growing season, and there was no peak in height growth at any time during the growing season.

In greenhouse studies it is often necessary to break dormancy of seedlings during the winter. Kramer (31) found he could break the dormancy of yellow-poplar by either exposing seedlings to low temperatures or treating the seedlings with ethylene chlorohydrin; and combination of the two treatments was even more effective in advancing the date for breaking dormancy.

Even though seedlings of yellow-poplar and many other hardwoods have no leaves in winter, they have been found to transpire during the winter at about the same rate, on the basis of unit area exposed, as conifers do (30).

SAPLING STAGE TO MATURITY

Growth and Yield

Mature yellow-poplar may reach 190 feet in height and 10 feet in diameter (24), but trees approaching this size are now rare. Good second-growth stands may attain heights of over 120 feet and diameters of 18 to 24 inches in 50 to 60 years. Probable yields for various ages and sites are shown in table 1, which was adapted from McCarthy (38).

Table 1.--Normal yield per acre for second-growth yellow-poplar [1]

Age (Years)	Basal area by site indices of--			Volume [2] by site indices of--			Volume [3] by site indices of--		
	70	90	110	70	90	110	70	90	110
	--Square feet--.			--Cubic feet--			--Board-feet--		
10	--	8	17	--	50	250	--	--	200
20	39	60	75	600	1,180	1,765	650	2,000	5,180
30	70	97	116	1,305	2,300	3,320	2,650	8,710	15,600
40	97	128	150	2,010	3,390	4,800	6,780	16,300	27,350
50	122	157	183	2,705	4,480	6,220	11,400	24,400	40,200

1/ All trees 5 inches or more d.b.h.
2/ Peeled volume of merchantable stem to a 3-inch top diameter inside bark.
3/ International 1/8-inch rule. Stump height 1 foot; top diameter inside bark 6 inches.

Typical second-growth yellow-poplar stand 45 years of age. This stand occupies a bottom-land site which at one time was a cultivated field.

In a study in West Virginia, the average diameter growth of yellow-poplar for the last 10 years by diameter classes was as follows (21):

Present d.b.h. (Inches)	D.b.h. growth in last 10 years (Inches)
6	3.55
8	3.37
10	3.19
12	3.00
14	2.82
16	2.64
18	2.46
20	2.28
22	2.09
24	1.91

Vigor classes as used by Campbell (7), Burkle and Guttenberg (6), and Holcomb and Bickford (21) reflect not only size of crown, but also the general thrift of the tree. Vigor classes have been correlated with diameter growth and used in studies of economic maturity for yellow-poplar and other species. For example, in the Southern Appalachians, yellow-poplar reaches economic maturity for sawtimber at from 18 to 26 inches d.b.h., the exact size depending upon the vigor of the tree and the interest rate used (7). The following tabulation showing financial maturity for upland yellow-poplar in Alabama (6) illustrates the key role of vigor class and concomitant diameter growth.

Vigor (Class)	3-percent interest (D.b.h.)	4-percent interest (D.b.h.)
High	30-31	26-27
Medium	26-27	22-24
Low	21-22	19-21

Yellow-poplar plantations at about age 20 years often show mean annual growth rates of 1 to 1½ cords per acre, depending on site and density of stocking. A 17-year-old plantation on an excellent stream-bottom site in central Georgia carried a total basal area of 153 square feet and 30 cords of wood per acre (44).

Reaction to Competition

Being an intolerant species, yellow-poplar cannot withstand severe competition. It is able to overcome some competition simply because it grows so rapidly. In the Piedmont and mountains of the Southeast, yellow-poplar is extremely sensitive to site change; on the very best sites it showed the highest site index of any species of hardwoods or conifers studied, and on the poorest sites it showed the lowest site index (45, 51).

The place of yellow-poplar in succession, as a pure type, is temporary. It often comes in as a pioneer on abandoned or clearcut land where seed and soil moisture conditions are favorable, only to be in turn invaded by more tolerant species such as oaks, hickories, or northern hardwoods. Yellow-poplar even more often regenerates as a mixed type with other species, and it commonly persists in climax stands as scattered individuals.

Because of the intolerance of this species, cleaning young seedlings or saplings is an important part of its management. Dominant and codominant yellow-poplar seedlings or saplings do not respond well to cleaning, but good-vigor trees in overtopped and intermediate crown classes respond quite readily in terms of both greater height and diameter growth (16). In a study of cleaning yellow-poplar in the Southern Appalachians, Abell (1) and Wahlenberg (57) showed that the greatest benefit at 10 and 25 years

after cleaning, respectively, was in the increased number of desirable stems and a better species composition. The cleaning also resulted in an increased yield of 6 cords of wood at the 25-year mark.

Yellow-poplar prunes itself well except in very sparsely stocked stands. Therefore, artificial pruning will probably not be necessary unless yellow-poplar becomes a more important planted species and is grown on a short rotation at a wide spacing. In well stocked stands on good sites, individual tree growth may slow down about the twentieth year, and, unless the stands are thinned, crowding and the accompanying reduction in size of crown may continue until growth is seriously retarded.

In thinnings made at about 20 years of age the material will usually be large enough for pulpwood. A study in West Virginia (59) shows that moderate thinnings may be desirable at short intervals. This will keep the stand sufficiently closed so that epicormic branching will not be serious (58), nor will the danger from ice or glaze be as great as with heavier thinning (10).

Holsoe (22) states that desirable crown length of yellow-poplar can be maintained by repeated thinnings; 60-foot crown lengths are possible when trees reach 100 feet in height. He recommends moderate to heavy thinnings at 8- to 10-year intervals in which 30 to 40 percent of the volume is removed. Through such intensive management, it may be possible to obtain annual growth of nearly 1,000 board-feet per acre during the last half of the rotation. In the process, basal area growth will be increased, the rotation shortened, and the specific gravity and strength of the wood increased (23).

Principal Enemies

Yellow-poplar is considered to be unusually free from diseases. Though subject to various canker, stain, and decay fungi, it is seldom extensively damaged (5).

Discolorations of the wood are very common following any type of wounding, but these discolorations, except when associated with decay, do not affect strength of the wood.

Young yellow-poplar is susceptible to cankers caused by *Nectria magnoliae*, but these cankers soon heal over on dominant or codominant trees (27).

Although decay often follows top breakage (46) or butt wounds from fire (20), these decays may or may not become extensive, depending upon the size of the wound and the species of rot fungus. Most of the decay is caused by *Collybia velutipes*, *Pleurotus ostreatus*, *Hydnum erinaceus*, and *Polyporus versicolor*; in one study (38) *Armillaria mellea* was the most common rot affecting fire-damaged trees.

The common leaf spots caused by species of *Cercospora*, *Cylindrosporium*, *Gloeosporium*, *Phyllosticta*, and *Mycosphaerella* (61) do not result in excessive damage.

Sapstreak, a disease caused by the fungus Endoconidiophora virescens has been found killing an occasional tree. At present, this disease is very rare, and is known only in western North Carolina.

Yellow-poplar is also relatively free from insect damage, despite a few pests which attack the leaves, branches, and stem. The foliage is occasionally fed upon by larvae of miscellaneous butterflies and moths, and it is frequently attacked by the tulip gall fly (Thecodiplosis liriodendri), which causes purplish blister-galls to form on the leaves. The branches and twigs may be attacked by several species of scale insects, among the most important of which is the tulip tree scale (Toumeyella liriodendri). These attacks seldom affect the health of the tree seriously.

Borers may occasionally degrade lumber seriously by tunnelling in the sapwood or heartwood. Most important is the Columbian timber beetle (Corthylus columbianus), a very aggressive ambrosia beetle which enters the sapwood of living trees (14). The defect, known as "calico poplar," consists not only of black-stained burrows, but discoloration may extend in the wood for a foot or more both above and below the point of attack. Dying trees and logs may be injured by the sapwood timber worm (Hylecostus lugubris), and the heartwood beneath blazes and wounds is often riddled by the flatheaded sycamore borer (Chalcophora campestris).

Because of the extremely thin bark, yellow-poplar seedlings and saplings are extremely susceptible to fire damage (38), and even a light ground fire is usually fatal to stems up to an inch in diameter. On large trees, when the bark reaches a thickness of a half inch or more, good insulation is provided against all but the hottest fires. Even then an entry may be provided for heartrot which will subsequently cause a hollow-butted condition.

Sleet and glaze storms occurring periodically within most of the range of yellow-poplar can also cause considerable damage (10, 38). Slender trees may be broken off, and stump sprouts are particularly susceptible to injury. Dominant and codominant trees often suffer top breakage which, if severe enough, will reduce the growth rate. This top damage often causes the trees to be infected with top rotting fungi at the point of injury. Although this species usually makes remarkable recovery after such storms, repeated damage can result in a serious reduction in rate of growth and general quality of the tree. Other enemies of this species include the sapsucker (Sphyrapicus vaius), which causes considerable degrade in the lumber, grapevines (Vitus sp.), which reduce the growth and sometimes kill the trees, and Japanese honeysuckle (Lonicera japonica), which is particularly serious because it thrives on the best sites, smothering small yellow-poplar saplings and precluding regeneration.

Frost damage to young yellow-poplar in certain localities, and the retarding effect which frost, especially in frost pockets, can have on the early growth and development of the tree, may have been overlooked somewhat in the past.

SPECIAL FEATURES

It has been reported that a yellow-poplar tree of less than 20 years of age will yield about 8 pounds of nectar or about 4 pounds of honey per season (38). Thus, the income from a stand of yellow-poplar may be greatly enhanced by keeping bees in the stand. As mentioned earlier, the more bees in a stand, the better the chances will be for more complete pollination and consequently a higher percentage of filled seed.

RACES AND HYBRIDS

There are no known natural hybrids of yellow-poplar, but the possible existence of races and geographic strains is being studied (34, 36).

After the third growing season, seedlings of North Carolina Coastal Plain origin were almost twice as high as seedlings that originated in the mountains of North Carolina (36). These seedlings are growing together in the Coastal Plain near Charleston, South Carolina.

It appears that seed from southern latitudes may have a lower germinative capacity and may produce less frost-hardy plants than seed from northern latitudes.

Yellow-poplar seedlings show distinct racial variation in a study at the Santee Research Center. At left, the North Carolina mountain source is only 4.4 feet in height in its third growing season. At right, the North Carolina Coastal Plain source of the same age is 7.9 feet in height.

LITERATURE CITED

(1) Abell, Charles A.
1935. Results of 1924 cleanings of cove hardwoods, Pisgah National Forest. Jour. Forestry 33: 626-627.

(2) Auten, John T.
1935. Successful forest planting requires better site appraisals. Jour. Forestry 33: 861-864.

(3) _____
1945. Prediction of site index for yellow-poplar from soil and topography. Jour. Forestry 43: 662-668.

(4) Bailey, L. F.
1948. Figured wood: a study of methods of production. Jour. Forestry 46: 119-125.

(5) Boyce, John Shaw
1948. Forest pathology. Ed. 2, 550 pp., illus. New York.

(6) Burkle, Joseph L., and Guttenberg, Sam
1952. Marking guides for oaks and yellow-poplar in the southern uplands. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 125, 27 pp., illus. (Processed.)

(7) Campbell, Robert A.
1955. Tree grades and economic maturity for some Appalachian hardwoods. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 53, 22 pp., illus. (Processed.)

(8) Carpenter, I. W., and Guard, A. T.
1950. Some effects of cross-pollination on seed production and hybrid vigor of tulip tree. Jour. Forestry 48: 852-855, illus.

(9) Carvell, Kenneth L., and Korstian, C. F.
1955. Production and dissemination of yellow-poplar seed. Jour. Forestry 53: 169, 170.

(10) Carvell, Kenneth L., Tryon, E. H., and True, R. P.
1957. Effects of glaze on the development of Appalachian hardwoods. Jour. Forestry 55: 130-132, illus.

(11) Chapman, A. G.
1935. The effects of black locust on associated species with special reference to forest trees. Ecol. Monog. 5: 37-60, illus.

(12) Chapman, A. G., and Lane, R. D.
1951. Effects of some cover types on interplanted forest tree species. U. S. Forest Serv. Central States Forest Expt. Sta. Tech. Paper 125, 15 pp. (Processed.)

(13) Coile, Theodore S.
1948. Relation of soil characteristics to site index of loblolly and shortleaf pines in the lower Piedmont region of North Carolina. Duke Univ. School of Forestry Bul. 13, 78 pp., illus.

(14) Craighead, F. C.
1950. Insect enemies of eastern forests. U. S. Dept. Agr. Misc. Pub. 657, 679 pp., illus.

(15) Deitschman, Glenn H.
1956. Growth of underplanted hardwoods in black locust and shortleaf pine plantations. U. S. Forest Serv. Central States Forest Expt. Sta. Note 94. (Processed.)

(16) Downs, A. A.
1946. Response to release of sugar maple, white oak,and yellow-poplar. Jour. Forestry 44: 22-27.

(17) Frothingham, E. H.
1931. Timber growing and logging practice in the southern Appalachian region. U.S. Dept. Agr. Tech. Bul. 250, 93 pp., illus.

(18) Guard, Arthur T., and Wean, Robert E.
1941. Seed production in the tulip poplar. Jour. Forestry 39: 1032, 1033.

(19) Harrar, Ellwood S., and Harrar, J. George
1946. Guide to southern trees. 712 pp., illus. New York.

(20) Hepting, George H., and Hedgcock, George G.
1937. Decay in merchantable oak, yellow-poplar, and basswood in the Appalachian region. U. S. Dept. Agr. Tech. Bul. 570, 30 pp., illus.

(21) Holcomb, Carl J., and Bickford, C. Allen
1952. Growth of yellow-poplar and associated species in West Virginia...a guide to selective cutting. U. S. Forest Serv. Northeast. Forest Expt. Sta. Paper 52, 28 pp. (Processed.)

(22) Holsoe, Torkel
1950. Profitable tree forms of yellow-poplar. West Virginia Univ. Agr. Expt. Sta. Bul. 341, 23 pp., illus.

(23) _____
1951. Yellow-poplar: reaction to crown release and other factors influencing growth. West Virginia Univ. Agr. Expt. Sta. Bul. 344 T, 83 pp., illus.

(24) Hough, Romeyn Beck
1907. Handbook of the trees of the northern states and Canada. 470 pp., illus. New York.

(25) Huckenpahler, B. J.
1955. Auxins fail to stimulate rooting of yellow-poplar cuttings. Bot. Gaz. 117(1): 73-75.

(26) Illick, J. S.
1919. When trees grow. Amer. Forestry 25: 1386-1390, illus.

(27) Jemison, George M., and Hepting, George H.
1949. Timber stand improvement in the Southern Appalachian region. U. S. Dept. Agr. Misc. Pub. 693, 80 pp., illus.

(28) Kienholz, Raymond
1941. Seasonal course of height growth in some hardwoods in Connecticut. Ecol. 22: 249-258, illus.

(29) Korstian, C. F., and MacKinney, A. L.
1931. Planting versus direct seeding of yellow-poplar in the Southern Appalachian region. Jour. Forestry 29: 1178-1181.

(30) Kozlowski, Theodore T.
1943. Transpiration rates of some forest tree species during the dormant season. Plant Physiol. 18: 252-260, illus.

(31) Kramer, Paul J.
1934. Methods of breaking dormancy in certain forest trees. Jour. Forestry 32: 734-741.

(32) _____
1943. Amount and duration of growth of various species of tree seedlings. Plant Physiol. 18: 239-251, illus.

(33) Limstrom, G. A., Finn, Raymond F., and Deitschman, Glenn H.
1953. How to grade yellow-poplar planting stock. U. S. Forest Serv. Central States Forest Expt. Sta. Notes 81. (Processed.)

(34) Limstrom, Gustaf A., and Finn, Raymond F.
1956. Seed source and nursery effects on yellow-poplar plantations. Jour. Forestry 54: 828-831, illus.

(35) Little, Elbert L., Jr.
1953. Check list of native and naturalized trees of the United States (including Alaska). U. S. Dept. Agr. Handbook 41, 472 pp.

(36) Lotti, Thomas
1955. Yellow-poplar height growth affected by seed source. Tree Planters' Notes 22, p. 3.

(37) Martin, Alexander C., Zim, Herbert S., and Nelson, Arnold L.
1951. American wildlife and plants. 500 pp., illus. New York.

(38) McCarthy, E. F.
1933. Yellow poplar characteristics, growth,and management. U. S. Dept. Agr. Tech. Bul. 356, 58 pp., illus.

(39) Merz, Robert W., and Finn, Raymond F.
1955. Yellow-poplar responds to preplanting ground treatment. U. S. Forest Serv. Central States Forest Expt. Sta. Tech. Paper 150, 18 pp., illus. (Processed.)

(40) Minckler, Leon S.
1941. Forest plantation success and soil-site characteristics on old fields in the great Appalachian valley. Proc. Soil Sci. Soc. Amer. 6: 396-398, illus.

(41) _____
1941. The right tree in the right place. Jour. Forestry 39: 685-688.

(42) _____
1946. Old field reforestation in the great Appalachian valley as related to some ecological factors. Ecol. Monog. 16: 88-108, illus.

(43) _____
1948. Tree planting in the central, piedmont, and southern Appalachian regions. U. S. Dept. Agr. Farmers' Bul. 1994, 39 pp., illus.

(44) Nelson, Thomas C., and Jackson, L. W. R.
1956. Yellow-poplar plantations. Forest Farmer 15(10): 11, illus.

(45) Nelson, Thomas C., and Beaufait, William R.
1957. Studies in site evaluation for southern hardwoods. Soc. Amer. Foresters Proc. 1956: 67-70, illus.

(46) Roth, Elmer R.
1941. Top rot in snow-damaged yellow poplar and basswood. Jour. Forestry 39: 60-62.

(47) Sargent, Charles Sprague
1933. Manual of the trees of North America (exclusive of Mexico). Ed. 2. 910 pp., illus. Boston and New York.

(48) Shipman, Robert D., and Rudolph, Victor J.
1954. Factors influencing height growth of planted yellow-poplar in southwestern Michigan. Mich. State Col. Dept. Forestry Tech. Bul. 242. 44 pp., illus.

(49) Sims, I. H.
1932. Establishment and survival of yellow poplar following a clear cutting in the Southern Appalachians. Jour. Forestry 30: 409-414, illus.

(50) Society of American Foresters
1954. Forest cover types of North America (exclusive of Mexico). Soc. Amer. Foresters, 67 pp., illus. Washington, D. C.

(51) Southeastern Forest Experiment Station
1955. Annual Report, 1954. U S. Forest Serv., Southeast. Forest Expt. Sta. Paper 50, 101 pp., illus. (Processed.)

(52) Toumey, J. W.
1929. Initial root habits in American trees and its bearing on regeneration. Internatl. Cong. Plant Sci. Proc. 1: 713-728.

(53) Tryon, E. H., and Meyers, C. A.
1952. Periodic precipitation affects growth of yellow-poplar on a West Virginia hillside. Castanea 17: 97-102.

(54) U. S. Department of Agriculture
1941. Climate and man. Agr. Yearbook 1941, 1248 pp., illus.

(55) U. S. Forest Service
1948. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.

(56) Van Dersal, William R.
1938. Native woody plants of the United States, their erosion-control and wildlife values. U. S. Dept. Agr. Misc. Pub. 303, 362 pp., illus.

(57) Wahlenberg, W. G.
1950. A long-term test; a quarter century of forest regrowth in a cut-over and cleaned Appalachian cove. South. Lumberman 181(2273): 183-187, illus.

(58) _____
1950. Epicormic branching of young yellow-poplar. Jour. Forestry 48: 417-419, illus.

(59) _____
1952. Thinning yellow-poplar in second-growth upland hardwood stands. Jour. Forestry 50: 671-676, illus.

(60) Wean, R. E., and Guard, A. T.
1940. The viability and collection of seed of liriodendron tulipifera. Jour. Forestry 38: 815, 816, illus.

(61) Westcott, Cynthia
1950. Plant disease handbook. 746 pp., illus. New York.

(62) Williston, Hamlin L., and Huckenpahler, Bernard J.
1957. Hardwood underplanting in north Mississippi. Jour. Forestry 55: 287-290.

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